

1 **Claims**

2 What is claimed is:

3 1. A method comprising:

4 generating a base layer bitstream and a plurality of independent
5 enhancement layer bitstreams of a first video frame, each bitstream encoded from
6 the first video frame and an associated high-quality reference image having an
7 associated high quality reference bit-rate;

8 determining a switching bit-rate associated with an available bandwidth of a
9 network; and
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11 selecting a first independent enhancement layer bitstream from the plurality
12 of independent enhancement layer bitstreams of the first video frame based on the
13 switching bit-rate.
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16 2. A method as recited in claim 1 wherein the generating operation
17 comprises concurrently generating the plurality of independent enhancement layer
18 bitstreams.
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20 3. A method as recited in claim 1 further comprising:

21 generating a plurality of independent enhancement layer bitstreams of a
22 second video frame, each bitstream being generated from the second video frame
23 using the associated high quality reference bit-rates;
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1 selecting a second independent enhancement layer bitstream from the
2 plurality of independent enhancement layer bitstreams of the second video frame;
3 and
4 generating a difference bitstream representing a difference between the first
5 selected independent enhancement layer bitstream and the second selected
6 independent enhancement layer bitstream.
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9 4. A method as recited in claim 1 wherein the determining operation
10 comprises estimating a switching bit-rate associated with two of the plurality of
11 independent enhancement layer bitstreams, such that distortion values associated
12 with transmission of the two enhancement layer bitstreams are substantially equal.
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14 5. A method as recited in claim 1 wherein the determining operation
15 comprises:
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17 estimating a switching bit-rate between a pair of the high quality reference
18 bit-rates of two of the plurality of independent enhancement layer bitstreams, the
19 estimated switching bit-rate based on distortion values associated with
20 transmission of the two enhancement layer bitstreams; and
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22 adding a buffer bit-rate to the estimated switching bit-rate, the buffer bit-
23 rate corresponding to a level of fluctuation of the network bandwidth.
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1 6. A method as recited in claim 1 wherein the high quality reference
2 bit-rates associated with the enhancement layer bitstreams are successively higher.

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4 7. A method as recited in claim 1 wherein the determining operation
5 comprises computing a switching bit-rate as a function of at least two high quality
6 reference bit-rates associated with two adjacent enhancement layer bitstreams in
7 the plurality of enhancement layer bitstreams.
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10 8. A method as recited in claim 7 wherein the computing operation
11 comprises computing an average bit-rate between the at least two high quality
12 reference bit-rates.
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15 9. A method as recited in claim 1 further comprising encoding the base
16 layer bitstream and the plurality of enhancement layer bitstreams according to an
17 H.26 video standard.
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19 10. A method as recited in claim 1 further comprising transmitting the
20 base layer bitstream and the first independent enhancement layer bitstreams.
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23 11. A method as recited in claim 1 further comprising:
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1 receiving the base layer bitstream and the first independent enhancement
2 layer bitstream; and
3 decoding the base layer bitstream and the first independent enhancement
4 layer bitstream to display the first video frame on a display device.
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6 12. A method as recited in claim 1 wherein the generating operation
7 further comprises:
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9 generating the base layer bitstream by applying motion estimation to the
10 first video frame and a plurality of high-quality reference images having associated
11 high quality reference bit-rates.
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1 13. A computer-readable medium having stored thereon computer-
2 executable instruction for performing a method comprising:
3 in a first video frame, transmitting a first enhancement layer bitstream
4 encoded at a first high quality reference bit-rate (HQRB);
5 detecting a change in network bandwidth from a first bandwidth that is less
6 than a predetermined switching bit-rate to a second bandwidth that is greater than
7 the predetermined switching bit-rate; and
8 in response to the detecting, switching up to a second enhancement layer
9 bitstream in a second video frame, the second enhancement layer bitstream
10 encoded at a second high quality reference bit-rate (HQRB), the second HQRB
11 being greater than the first HQRB.
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14 14. A computer-readable medium as recited in claim 13, the method
15 further comprising:
16 in the second video frame, transmitting an enhancement layer difference
17 bitstream representing the difference between the first enhancement layer bitstream
18 and the second enhancement layer bitstream.
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21 15. A computer-readable medium as recited in claim 13, the method
22 further comprising:
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transmitting a base layer bitstream in both the first video frame and the second video frame, the base layer bitstream encoded at a base bit-rate that is less than the first HQRB, the base layer bitstream serving as a reference for the first enhancement layer bitstream and the second enhancement layer bitstream.

16. A computer-readable medium as recited in claim 13, the method further comprising:

in a third video frame, switching down to the first enhancement layer bitstream in response to detecting a change in network bandwidth from the second bandwidth to the first bandwidth.

17. A computer-readable medium as recited in claim 13, further comprising encoding the first enhancement layer bitstream and the second enhancement layer bitstream according to a Motion Picture Experts Group (MPEG) video encoding standard.

18. A computer-readable medium as recited in claim 13, wherein the predetermined switching bit-rate is a function of the first HQRB and the second HQRB.

1 19. A computer-readable medium as recited in claim 13, wherein the
2 predetermined switching bit-rate is a bit-rate at which a distortion value associated
3 with transmission of the first enhancement layer bitstream is substantially equal to
4 a distortion value associated with transmission of the second enhancement layer
5 bitstream.
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8 20. A computer-readable medium as recited in claim 15 further
9 comprising applying motion estimation to at least one of a high quality reference
10 of the first enhancement layer bitstream and a high quality reference of the second
11 high quality reference bitstream to generate the base layer bitstream.
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1 21. A system comprising:
2 a data encoder generating a base layer bitstream encoded at a base bit-rate,
3 and a plurality of enhancement layer bitstreams, each enhancement layer bitstream
4 encoded at a different enhancement layer bit-rate; and
5 an enhancement layer bitstream selection module selecting one of the
6 enhancement layer bitstreams in each of a plurality of video frames based on a
7 switching bit-rate, the switching bit-rate being a function of two of the
8 enhancement layer bit-rates.
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11 22. A system as recited in claim 21 wherein each of the enhancement
12 layer bitstreams is independently based on the base layer bitstream.
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15 23. A system as recited in claim 21 wherein the data encoder comprises:
16 a base layer bitstream encoder receiving video data and generating the base
17 layer bitstream; and
18 a plurality of enhancement layer bitstream encoders, each enhancement
19 layer bitstream encoder receiving the base layer bitstream and the video data and
20 concurrently generating an associated one of the plurality of enhancement layer
21 bitstreams representing a successively higher level of resolution from the base
22 layer bitstream.
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1 24. A system as recited in claim 21 further comprising a difference layer
2 bitstream encoder generating a difference layer bitstream representing a difference
3 between a first selected one of the plurality of enhancement layer bitstreams
4 transmitted in a first video frame and a second selected one of the plurality of
5 enhancement layer bitstreams transmitted in a second video frame.
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8 25. A system as recited in claim 24 wherein the difference layer
9 bitstream is transmitted between the first selected one of the plurality of
10 enhancement layer bitstreams and the second selected one of the plurality of
11 enhancement layer bitstreams.
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13 26. A system as recited in claim 23 wherein the base layer bitstream
14 encoder comprises a motion estimator generating a base layer bitstream based on at
15 least one high quality reference bitstream and a current video frame.
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1 27. A method comprising:
2 in a first video frame, receiving a first enhancement layer bitstream encoded
3 at a first high quality reference bit-rate (HQRB);
4 in a second video frame, receiving a second enhancement layer bitstream
5 encoded at a second high quality reference bit-rate (HQRB), the second HQRB
6 being greater than the first HQRB;
7 receiving a difference bitstream representing a difference between the first
8 enhancement layer bitstream and the second enhancement layer bitstream; and
9 decoding the second enhancement layer bitstream based on the first
10 enhancement layer bitstream and the difference bitstream.
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1 28. A method comprising:
2 encoding a plurality of video frames from a video frame sequence into a
3 base layer and a plurality of enhancement layers;
4 for each video frame, selecting one of the enhancement layers to transmit
5 based on a relationship between a switching bit-rate and high quality reference bit-
6 rates associated with the enhancement layers and a detected network bandwidth;
7 and
8 transmitting a difference bitstream if a currently selected one of the
9 enhancement layers is different from a previously selected one of the enhancement
10 layers, the difference bitstream comprising an encoded difference between the
11 currently selected enhancement layer and the previously selected enhancement
12 layer.
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16 29. A method as recited in claim 28 further comprising:
17 estimating distortions associated with two of the plurality of enhancement
18 layers;
19 choosing the switching bit-rate such that the estimated distortions are
20 substantially equal.
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23 30. A method as recited in claim 28 further comprising:
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1 estimating distortions associated with two of the plurality of enhancement
2 layers;
3 choosing the switching bit-rate based on the estimated distortions are
4 substantially equal;
5 adjusting the switching bit-rate based on a buffer bit-rate.

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8 31. A method as recited in claim 28 further comprising truncating the
9 difference bitstream prior to transmission.
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